ALUMINUM

Project Fact Sheet

Thermomechanical Processing of Aluminum Alloys

Benefits

The fundamental insights and technology improvements derived from this research will translate into significant energy savings, and financial and environmental benefits to the aluminum industry. Estimated annual benefits include:

- Energy savings of 161 billion Btu
- Reduction of 161 million cubic feet of CO_2 emissions
- Financial benefit of $70 million

Applications

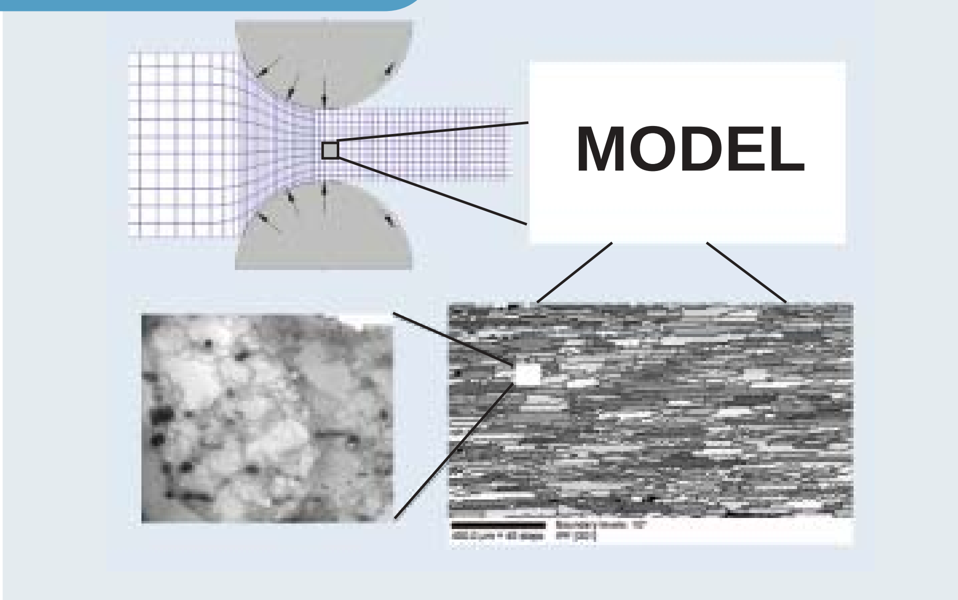
This project provides technological advancements and fundamental understanding of the thermomechanical processing of metal. The availability of this model will enable aluminum researchers and engineers to analyze process design problems systematically and analytically, and to search for optimal operating conditions.

Development of integrated methodology for thermo-mechanical processing of aluminum alloys

Current processes for heat treatment and rolling of aluminum alloys require substantial energy and material cost. A better understanding of the physics of deformation and structure development will result in the opportunity to reduce alloy content, minimize processing steps, and improve performance of existing products. The fundamental understanding and resulting technology improvements will lead to significant energy savings. To achieve the energy savings, project partners will develop an integrated methodology for modeling local structural evolution during thermomechanical processing of rolled aluminum sheet for alloy design and manufacturing.

This research will involve developing a finite element-based integrated mechanical and microstructural model for process understanding and design sensitivity analyses. Validation of the integrated model predictions will be performed through bench-scale experimental measurements. The goal is to produce models that will allow simultaneous process modeling and alloy development. The integrated model will enable researchers to simultaneously address material dynamics and mechanical behavior for alloy design and for thermomechanical process optimization. The process optimization that results from this research will provide potentially significant energy savings as well as a faster/cooler approach to metal production and the potential to eliminate some heat treatment steps.

Finite Element Model



Finite element-based model for thermomechanical deformation and microstructure formation.

Project Description

Goals: The goal of this research is to develop an integrated finite element model that is capable of predicting mechanical deformation and microstructure evolution in polycrystalline aluminum alloys undergoing large strain plastic deformation.

The model will be verified through experimental measurements taken in channel die and uniaxial compression tests and will be deemed successful when the model predicts the observed microstructural development. The model will be the cornerstone upon which process optimization and alloy development for industrial manufacturing can be developed.

Progress and Milestones

Year One
- Build crystal plasticity capability into the Finite Element Modeling code
- Develop first-order constitutive behavior and dislocation structure evolution models
- Select recrystallization and precipitate coarsening models
- Test the deformation part of the model against experiments on well-defined structures

Year Two
- Complete iterations on the deformation models
- Validate recrystallization and coarsening models by experimental observation
- Outline and implement the parallel computational framework involved in the integrated model

Year Three
- Apply the integrated model to simulate aluminum alloy behavior during deformation and annealing
- Refine the structure evolution models
- Optimize the parallel computations
- Validate models with additional experiments

Commercialization Plan

Commercial adoption of the fundamental knowledge gained from this program will take place through the active participation of the industrial partners. In addition, the commercialization path is to transfer fundamental knowledge gained to a wide cross-section of the thermomechanical industry through public papers and presentations.

Project Partners

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Alcoa Technical Center
Alcoa Center, PA

Pacific Northwest National Laboratory
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